EMBRYOLOGY.[1]

Spina Bifida and the Blastopore.[2]—Prof. Oscar Hertwig has made an important contribution to teratology and attempted the solution of some fundamental morphological problems in a paper that is disappointing from many points of view, though undoubtedly of considerable value.

In order to produce polyspermy in the frog, eggs were kept two to four days in a moist chamber before artificial fertilization was attempted, or else the female frogs were isolated for four to six weeks. In either case very many eggs developed normally, yet it is assumed that the hundred monstrous forms picked out were the results of some injury made upon the egg by the above treatment and that polyspermy took place.

This latter assumption is in no wise supported by any direct observations, but rests merely upon the previous work done by the author and others upon other eggs.

Passing over some interesting cases of irregular and of partial cleavage we will briefly describe the three sorts of monstrosities assumed to be imperfect conditions of gastrula stages.

In the first case there is a large yolk plug appearing at the surface of the embryo all along the dorsal, median region, so that such a monstrous embryo of five to seven days looks as if there were a huge blastopore with a medullary fold along each side of it and a plug of yolk cells projecting between these folds. At each end of this plug a depression leads ventrally, a sort of fore gut and hind gut. At the posterior end two elevations represent a sort of double tail. In fact, the medullary groove or tube and the notochord are *double* and pass along each side of the yolk plug.

In a second set of abnormalities the embryos have advanced so far as to have eyes, external gill slits, a short tail and a heart. The tail is bent up at right angles to the trunk and anterior to it is a small plug of yolk coming to the surface on the median dorsal line. Internally the nerve tube and the notochord are double on each side of the yolk plug, or open blastopore, but anterior to that form normal, single structures. Posteriorly they run as paired organs into the tail, which

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[2]Archiv f. mikros. Anat., xxxix, 1892, pp. 353–492, plates 16–20.

usually appears a single structure externally but may be quite deeply bifid or double from the base. Posterior to the tail a median groove may run in to the digestive tract as an anal pit.

The third class of monstrosities presents only a slight departure from the normal, having a prominent yolk plug not closed in when the larva is even older than in the second class. This plug occupies the position of the normal blastopore or anus of Rusconi, posterior or ventral to the tail, and is due to a failure of the ventral lip of the blastopore to grow up as soon as it should have done.

In interpreting these peculiar abnormal embryos the author assumes that they are all cases of arrested development, that the yolk plug is in each case really the blastopore, which has failed to close at the proper time, thus causing the median dorsal parts of the embryo to appear as paired structures along the lateral lips of the huge, open blastopore, whereas, they normally would first appear as single structures along the median dorsal line when the blastopore had closed there. The retardation in the closure of this dorsal blastopore has thus kept dorsal structures separated till they have so far developed as to form half structures widely apart; later, when the blastopore closes, these halves may grow together more or less perfectly and so produce a normal form.

It is to be regretted that individual cases were not actually watched so that there might be no doubt concerning the real value of these great, dorsal, hernia-like yolk plugs.

The author thus definitely adopts the position, hitherto held only by Roux and opposed by Schultze, that the frog larva develops along what was the light-colored side of the egg, the blastopore closing in successively from the head towards the tail along this aspect of the egg. He regards the blastopore in the frog as a median, dorsal opening extending the whole length of the trunk, normally closing in till the anus of Rusconi and the definitive anus are left as evidences of its posterior portion, while anteriorly a median "rückenrinne" and the lateral origin of mesoblast and the relations of the notochord give evidence of its existence through the whole length of the animal.

Increase in length would not take place anterior to the closing blastopore so much as at the actual point of successive closing, the blastopore advancing posteriorly *pari pasu* with its gradual closing.

Hertwig takes a definite stand as a supporter of the concrescence theory of His, modifying it somewhat when extending it to all vertebrates by regarding the neurenteric canal as also a part of this dorsal blastopore.

In discussing the blastopore and concrescence in various vertebrates a sharp distinction is drawn between the true blastopore or depression leading into the digestive tract and the growing edge of the blastoderm, "Umwachsungsrand" as it may be called. Only part of the latter may, in some cases, become the blastopore. Thus in the bony fish the blastopore consists of a short transverse portion or sickle and a longitudinal constantly elongating and closing median groove running forward from the sickle. The sickle is gradually formed more and more from the edges of the blastoderm, the "Umwachsungsrand," till the latter is eventually used up in this way, becoming converted into sickle-groove, which in turn is gradually closed in along the median, dorsal line of the embryo. In the shark, however, the "Umwachungsrand" soon leaves the sickle and the partly closed in portion of the blastopore and then closes by itself; is not then part of the blastopore. In the chick or in a reptile this separation is such an early one that the true blastopore is quite removed from the edge of the circular growing edge of the blastoderm, which then is not to be reckoned as part of the blastopore at all.

The anus of vertebrates is regarded as the posterior part of this elongated blastopore, hence the vertebrate tail is morphologically, as in some of these monstrous frog embryos, a double structure growing out from the right and left lips of the blastopore. The tail, with its neural tube, notochord, mesoblastic somites and portion of the entoblast is then not a prolongation of the trunk, but a dorsal outgrowth of different value. It elongates by a transfer of the "Wachsthumszone" to its tips and in the same manner as the trunk elongated. How it is possible for the closing in process and growth to take place posterior to the tail and also at the tips of the tail the author does not explain.

Having brought forward some arguments for his coelom theory and replied to certain criticisms of Götte the author next discusses at length the relation of the blastopore to various abnormal forms in vertebrates. He takes the view that the formation of several embryos from a single egg is to be referred back to the formation of as many gastrula invaginations in that egg. The difference between such multiple monsters in different groups of vertebrates is then due to the differences in the gastrulation, to the various possible ways in which multiple invaginations may arise in different sorts of eggs. The apparent absence or great rarity of double monsters in the Amphibia may be due either to the small size of the egg and difficulty of double invagination or it may be that such doubleness is early obliterated by following fusion

into normal structures. In the bony fish the tendency to the formation of double-headed monsters would be due to the method of closure of the blastopore, two invaginations being easily brought together to form a common trunk. In the chick, however, this cannot so readily take place, but embryos arising peripherally on the blastoderm tend to have their heads fused while the tail ends are not brought together by the fusion of any growing edge forming the blastopore and so remain separate.

This leads to the consideration of the conditions producing double germs from a single egg. A single egg after the first cleavage has the power to produce two individuals of normal structure but half the normal size. This is the necessary result of the process of cell division as previously explained by the author, and has recently been shown experimentally by Driesch, Chabry and not really negatived by Roux, when his work is interpreted as seems just.

The first two cells of a cleaving oosperm develop into right and left halves only because of their association together; separated each would form a perfect organism.

The reason for the manifestation of this double power in double monsters is to be sought in the action of forces before cleavage. Of these the author regards polyspermy as the most efficient. This view the author upholds in spite of the many negative experiments that have been made upon echinoderm eggs (and upon frog eggs in the present paper, granting that polyspermy actually took place in the frog's eggs used).

Here it may be noted that the author assumes throughout that the frog's eggs were injured by the treatment he gave them, and that more than one sperm entered each abnormal one.

There is, however, no evidence of this in the present paper; we find only a certain similarity between the treatmont of the eggs and the treatment of echinoderm eggs when polyspermy actually ensued.

Back of the effects produced by entrance of many sperms there is the abnormal state of the egg allowing of this multiple fertilization.

This state of the egg with the effects of polyspermy remain latent until later several invaginations may result and from these eventually double monsters are formed if there be not a complete fusion of the first rudiments.

The connection between polyspermy and the formation of double monsters is thus by no means a direct nor a simple one, yet of the many factors concerned the effects of polyspermy are, in the author's estimation, the important ones.